Modeling the photosynthetic processes in the ORCHIDEE model and ways of improvement

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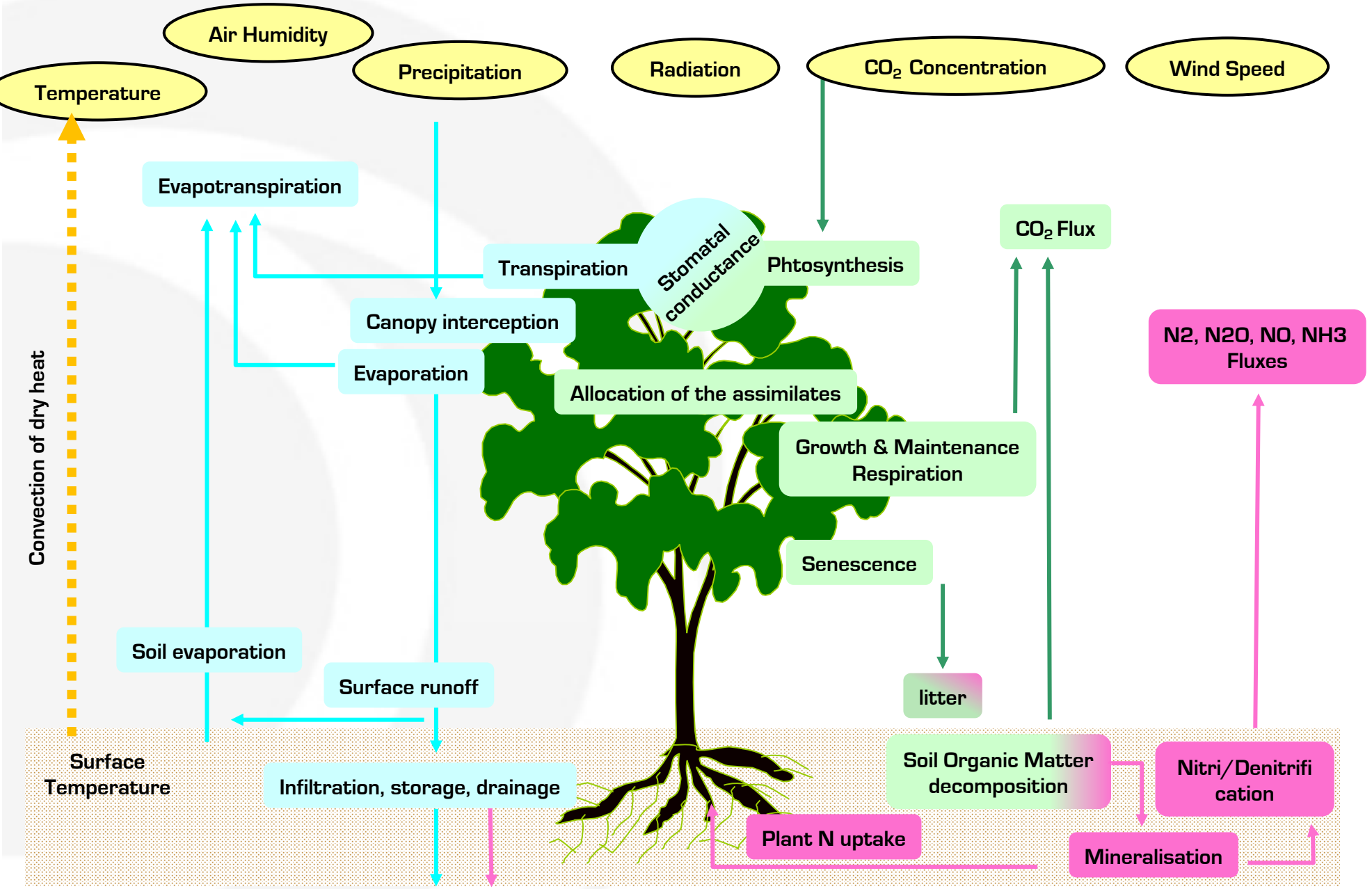
ORCHIDEE
LAND SURFACE MODEL

Coupling energy, water and carbon cycles



3 state variables / 3 equations

- The rate of [CO_2] assimilation, A
  - $A = \min(A_c, A_j)$

    where A_C *is the Rubisco-limited rate of* CO_2 *assimilation*

    A_j *is the e- transport-limited rate of* CO_2 *assimilation*
    - *Both* A_c *and* A_j *are function of* C_i

- The intercellular CO_2 partial pressure, C_i
  - $C_i = C_a - A\ (\ 1/g_b + 1/g_s\ )$

    where C_s is the leaf-surface CO_2 partial pressure

    g_b the boundary-layer conductance

- The stomatal conductance, g_s
  - $g_s = g_0 + (\ A + R_d\ ) / (\ C_i - C^*_i\ )\ f_{VPD}$

    where g_0 is the stomatal conductance when irradiance is 0

    R_d the dark respiration

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CO_2 assimilation by photosynthesis

- The Farquhar, von Caemmerer and Berry model (FvCB)
  - A_c, the Rubisco-limited rate of CO_2 assimilation

$$A_c = \frac{(C_i - \Gamma_*)V_{C\,max}}{C_i + K_{mC}(1 + O/K_{mO})} - R_d$$

Maximum rate of Rubisco activity-limited carboxylation (μmol CO_2 m^{-2} s^{-1})

  - A_j , the e- transport-limited rate of CO_2 assimilation

$$A_j = \frac{(C_i - \Gamma_*)J}{4C_i + 8\Gamma_*} - R_d$$

Rate of e- transport (μmol e- m^{-2} s^{-1})

$f = (irradiance, \ldots, J_{max})$

Maximum value at saturated light

Parametrization and co-dependancy of V_{cmax} and J_{max}

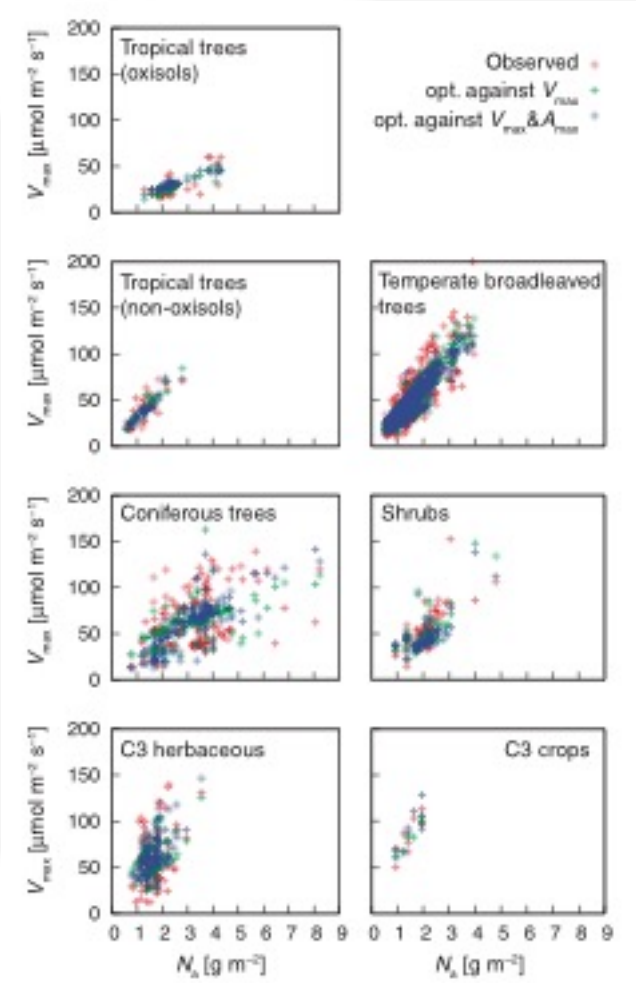
- $V_{C\,max,25} = NUE \times N_L$

where *NUE* is the Nitrogen Use Efficiency and N_L the leaf N content

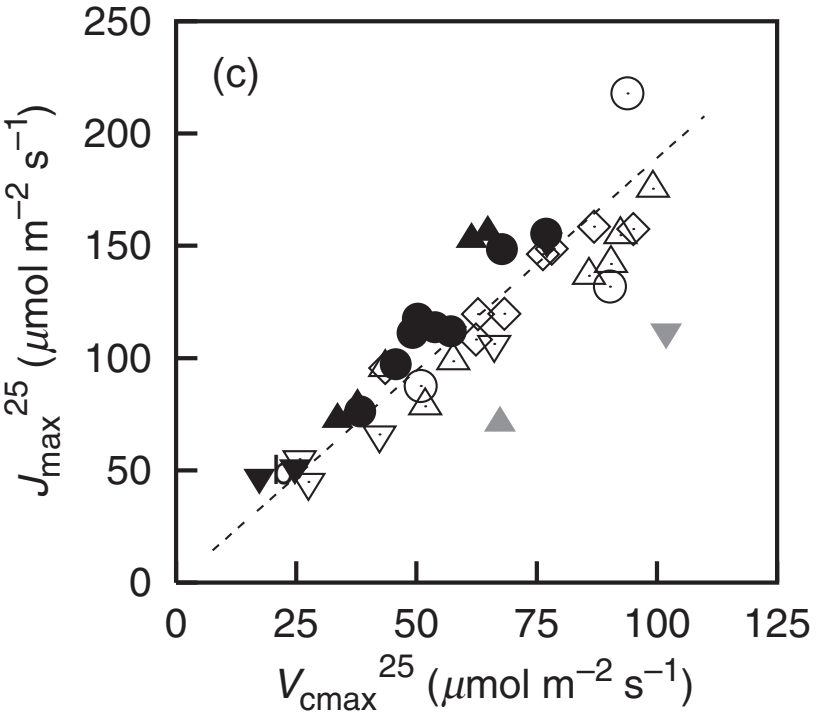
- $J_{max,25} = r_{J,V}\, V_{C\,max,25}$

where *NUE* is the Nitrogen Use Efficiency and N_L the leaf N content

$V_{C\,max}$ vs. Leaf N content

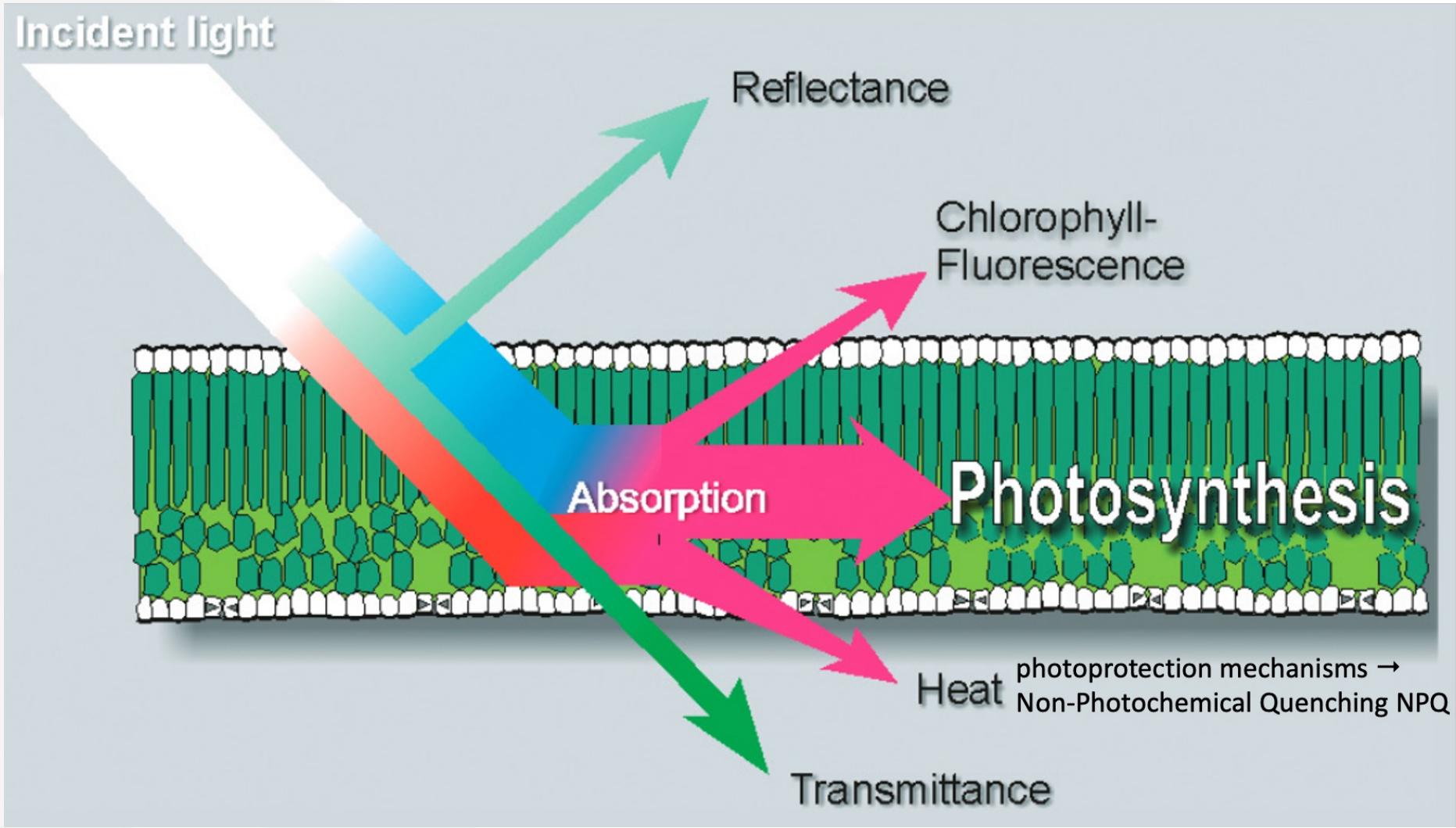


Kattge et al., 2009



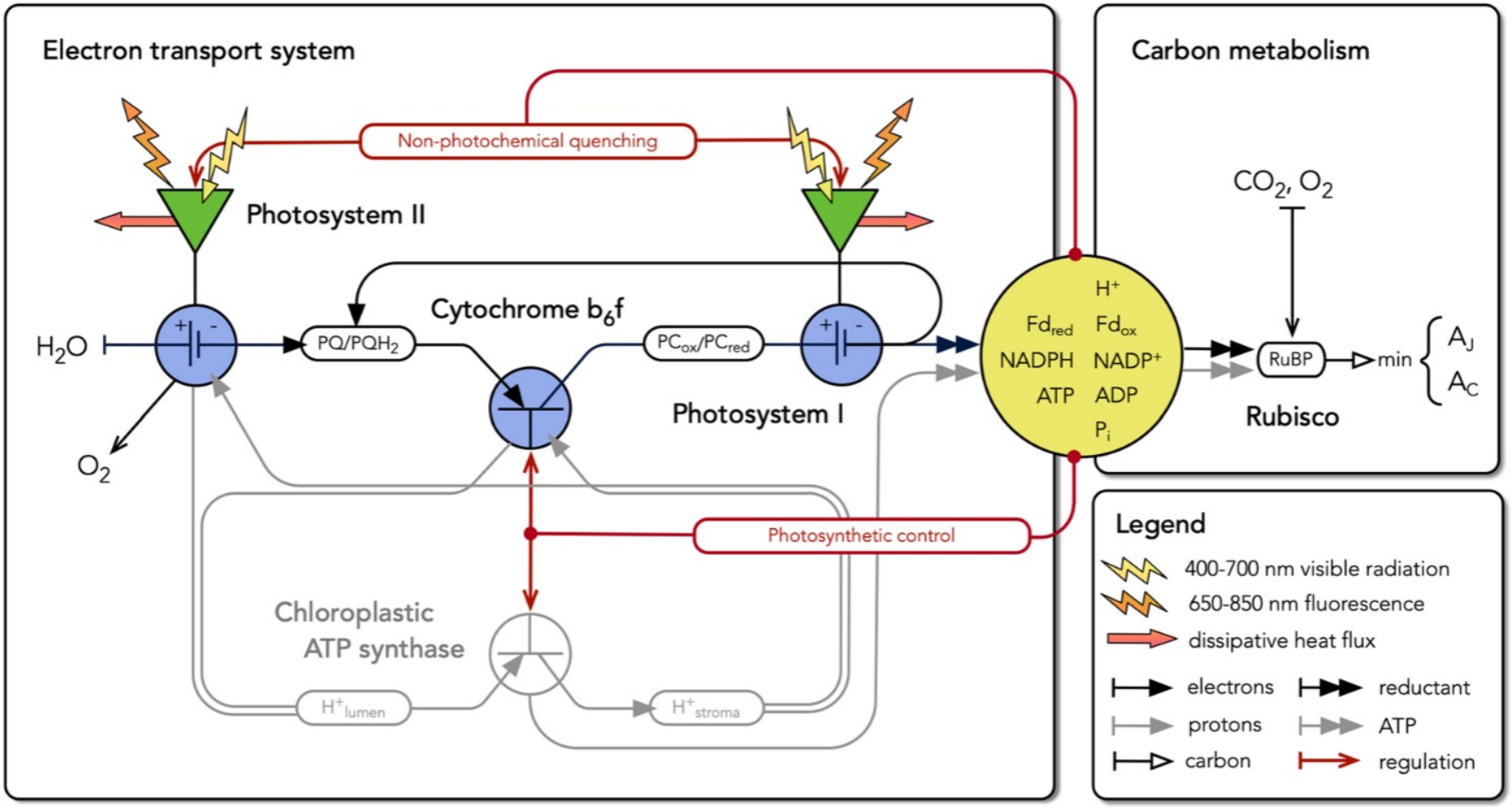
Kattge et al., 2007

Link between photosynthesis and fluorescence



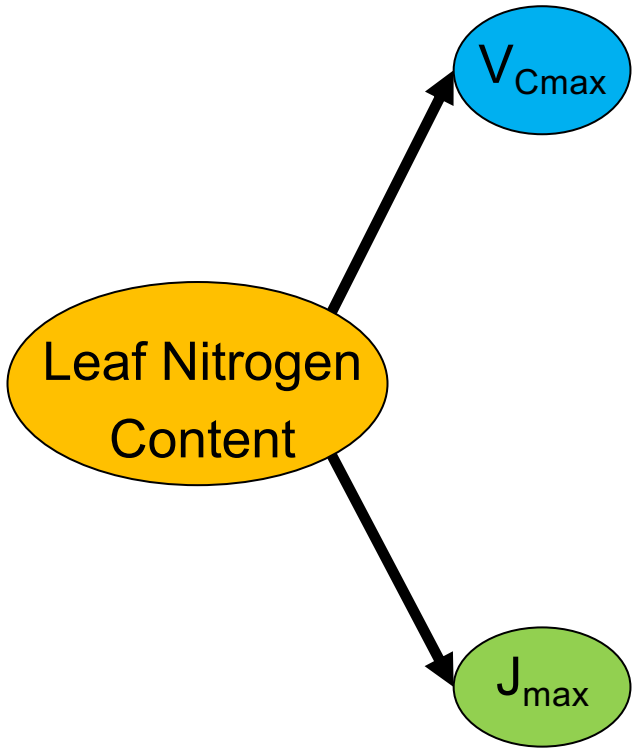
An extended model of the fate of absorbed light

- Extends the Farquhar model to include a mechanistic description of the electron transport system.
- First implementation done in ORCHIDEE



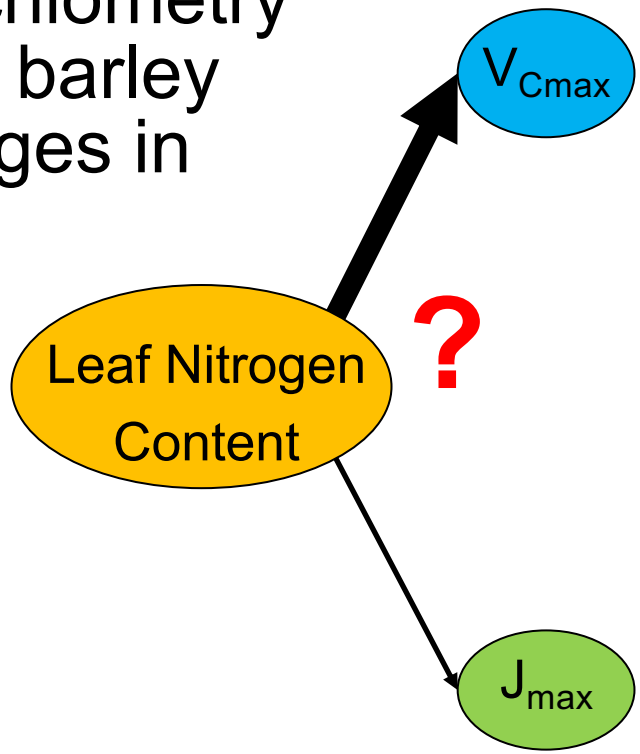
Johnson & Berry, 2021

ORCHIDEE in the GREENSCALE proposal



ORCHIDEE in the GREENSCALE proposal

- Can we reparametrize the V_{Cmax}/J_{max} stochiometry to represent the “Green Scale" panel of 8 barley varieties and simulate the observed changes in photosynthesis activity ?



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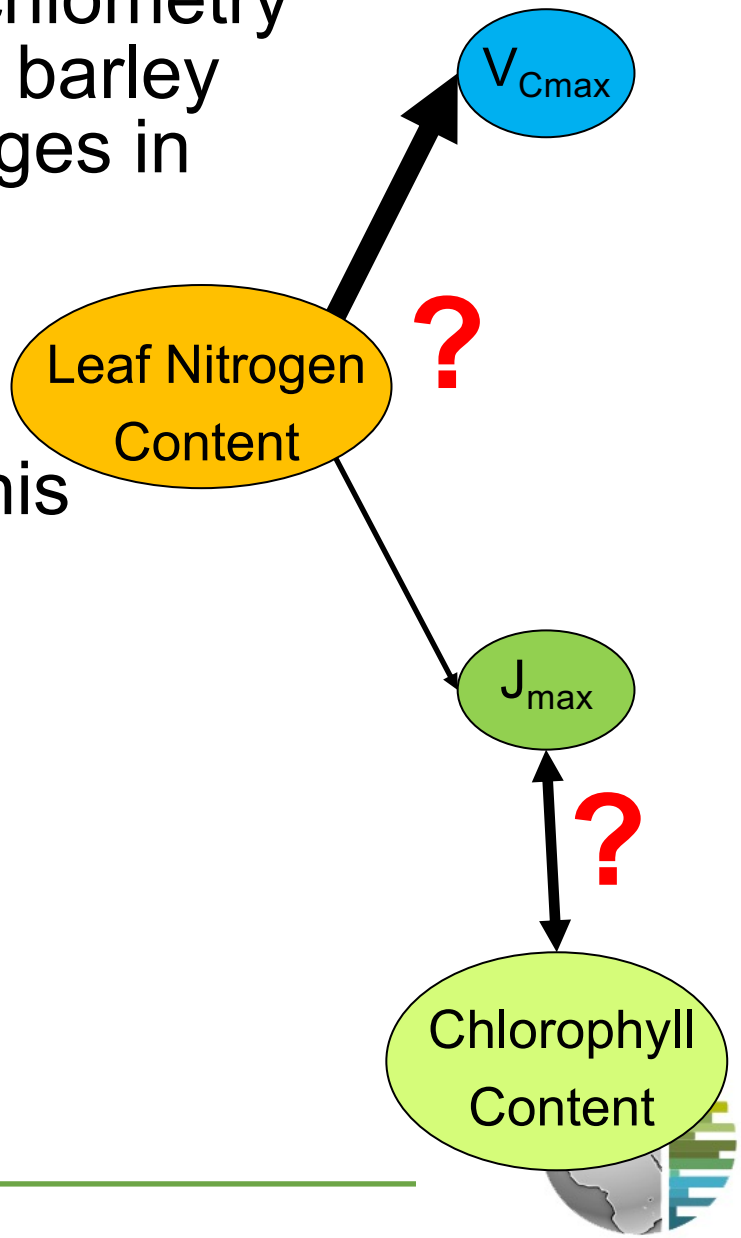

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- Can we simulate the observed Chl fluorescence at field scale and how this information may help to better constrain the FvCB photosynthetic and fluorescence model ?